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RESIDUAL RADIATION PATTERN FOR VARIOUS SURFACE WIND VELOCITIES - UNDERWATER ATOMIC BURST

AFSWP-155

Staff Study by Maj. T. A. Gibson, Jr., USA, 14 March 1952

In the event of an underwater atomic explosion in a harbor, it is of interest to have estimates of the extent and magnitude of the residual radiation field as a function of surface wind velocity. It is possible to make such estimates by using the information available from the Bikini-Baker underwater explosion.

Figure 8.101 of "The Effects of Atomic Weapons" (1) will be assumed to be correct. (Assumption No. 1) This gives the dose rate at 1 hour after the explosion as observed on ships. Had the contamination fallen on land, the rates would be increased by about a factor of four due to the absence of run off and the presence of a greater contaminated area. That is, after a short time, a ship is a limited contaminated area surrounded by an essentially uncontaminated area. The final results of this paper should be multiplied by 4 to be made applicable to land adjacent to an underwater burst.

Roger Revelle, in his "Characteristics of the Base Surge," (2) gives the observed movement of the Bikini-Baker surge. He also gives predicted surge movement for other surface winds. These will be assumed to be correct. (Assumption No. 2)

The pattern of the Bikini residual contamination was observed to lie in an area almost identical with the area covered by the base surge. It will be assumed that all of the residual cor[illegible]nation comes from the base surge. (Assumption No. 3)

The fourth and final assumption will be that the ti[illegible] rate of deposition of contaminant can be expressed as:

$$\frac{dD}{dt} = K/t^2 \quad \text{where: K is a constant to b[e] determined}$$

Integrating and letting, t_o = time of explosion
t_1 = time surge reaches an area
t_2 = time surge leaves an area

$$\int_o^{D_{t_2}} dD = \int_{t_1}^{t_2} K/t^2 \, dt$$

$$D_{t_2} = -K \; t^{-1} \Big/_{t_1}^{t_2}$$

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$$D_{t_2} = K \left\{ {}^1/t_1 - {}^1/t_2 \right\}$$

D_{t_2} = Amount of radioactive material on surface after base surge has passed over between times t_1 and t_2.

Since the dose rate at one hour at any point is directly proportional to the amount of radioactive material on the surface at that point, we can test the validity of this equation. We have a good estimate of the dose rate at one hour at various points, Figure 8.101, "The Effects of Atomic Weapons."(1) We have the observed movement of the surge, Revelle's paper.

So if,

$$\frac{\text{Dose rate at 1 hr}}{{}^1/t_1 - {}^1/t_2} = \text{Constant,}$$

our fourth assumption is valid. The following table shows that the assumption is valid.

Also listed are the results if one assumes $\frac{dD}{dt} = {}^K/t$ or $\frac{dD}{dt} = {}^K/t^3$.

Table Showing that Rate of Fall Out from Base Surge Equals ${}^K/t^2$

Distance downwind in miles	r/hr at 1 hr	$\frac{r/hr}{{}^1/t_1 - {}^1/t_2}$	$\frac{r/hr}{\ln t_1 - \ln t_2}$	$\frac{r/hr}{{}^1/t_1^2 - {}^1/t_2^2}$
.5	500	178	121	
.9	250			203
1.0	215	212	64	
1.4	120			309
1.5	100	213	36	
1.6	90			398
1.75	70			554
2.0	50	242	23	985
2.5	26	327	18	2360
3.0	13	279	11	
3.1	12			8920
3.5	7	232	3.5	

It is to be noted that the dose rate varies by a factor of 100, yet the figures in the third column are essentially constant over this wide range.

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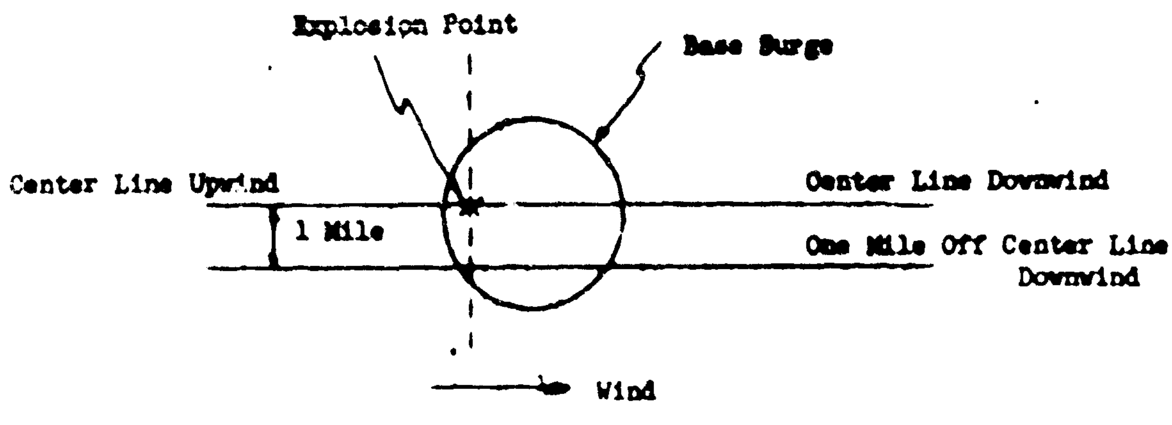
We now have a method of predicting the downwind dose rate one hour after the explosion at any distance for various surface winds. The method is to use Revelle's predictions for the movement of the surge in various winds. The time the surge reaches any point and the time it leaves the point are determined for various points and wind velocities. See Figures 1, 2, 3, and 4 for plots of these data. Then the dose rate at one hour at any point is given by,

$$\text{dose rate at one hour} = \frac{K}{{}^{1}/t_1 - {}^{1}/t_2},$$

where K is the average constant determined from the Bikini-Baker observations.

This dependence of downwind residual radiation on surface wind is shown in Figure 5.

A similar analysis can be applied along a center line drawn upwind from the point of the explosion and along a line displaced one mile off center and drawn downwind.

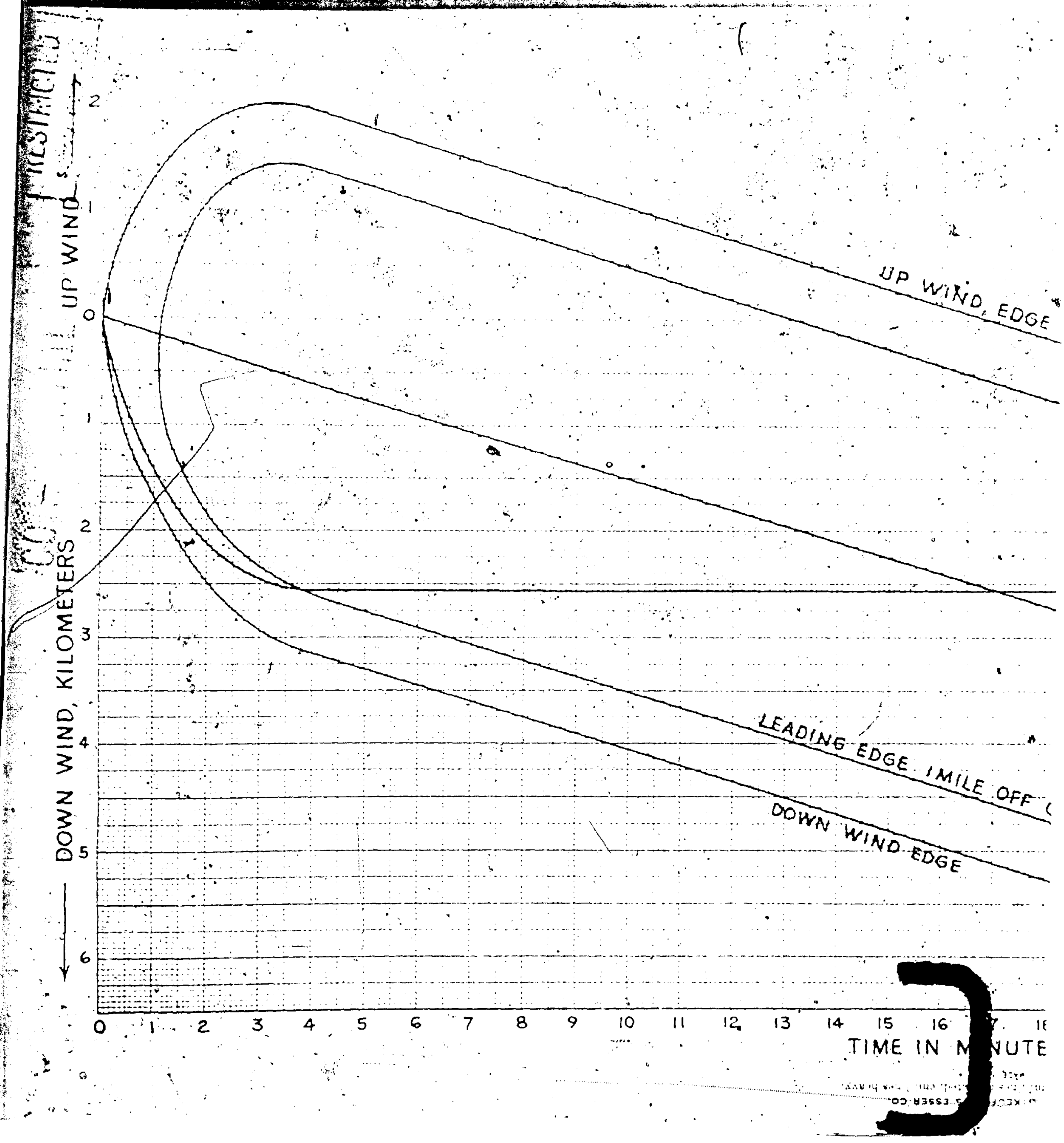


Figures 6 and 7 show the dependence of the residual contamination on wind velocity along these lines. The upwind data as given by Figure 8.101 of "The Effects of Atomic Weapons" have been adjusted to agree with the data of Figures 8.91a, b, and c. By using Figures 5, 6, and 7 one can obtain at least four points on a constant dose rate contour line and draw such contour patterns for various wind velocities. Examples of such contours are shown in Figures 8 and 9.

References:

1. "The Effects of Atomic Weapons," June 1950, U. S. Government Printing Office.

2. "Characteristics of the Base Surge" by Roger Revelle. AFSWP Technical Library File Number 10-5.


UP WIND
DOWN WIND, KILOMETERS
UP WIND EDGE
LEADING EDGE 1MILE OFF
DOWN WIND EDGE
TIME IN M NUTE
2
1
0
1
2
3
4
5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

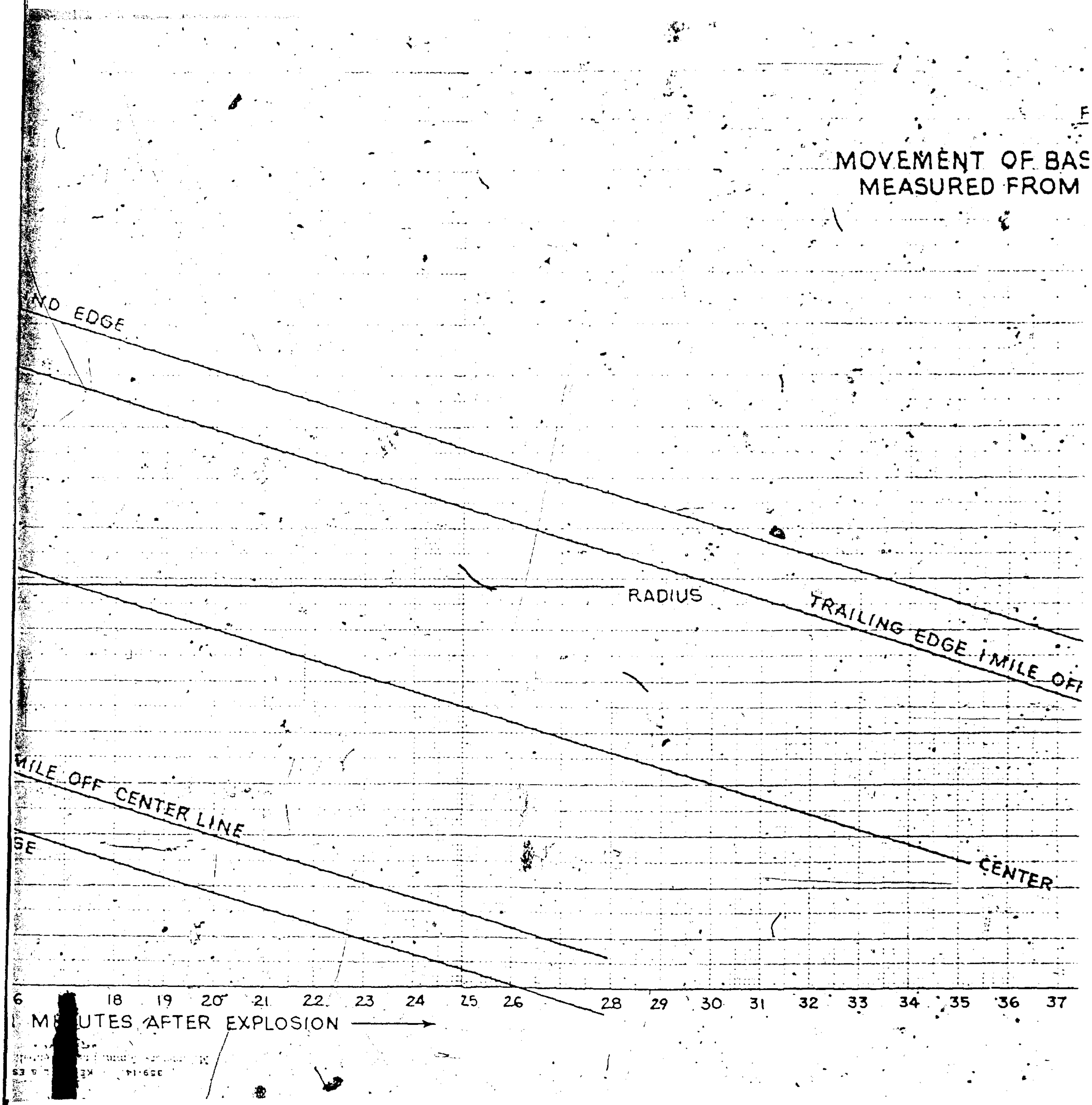
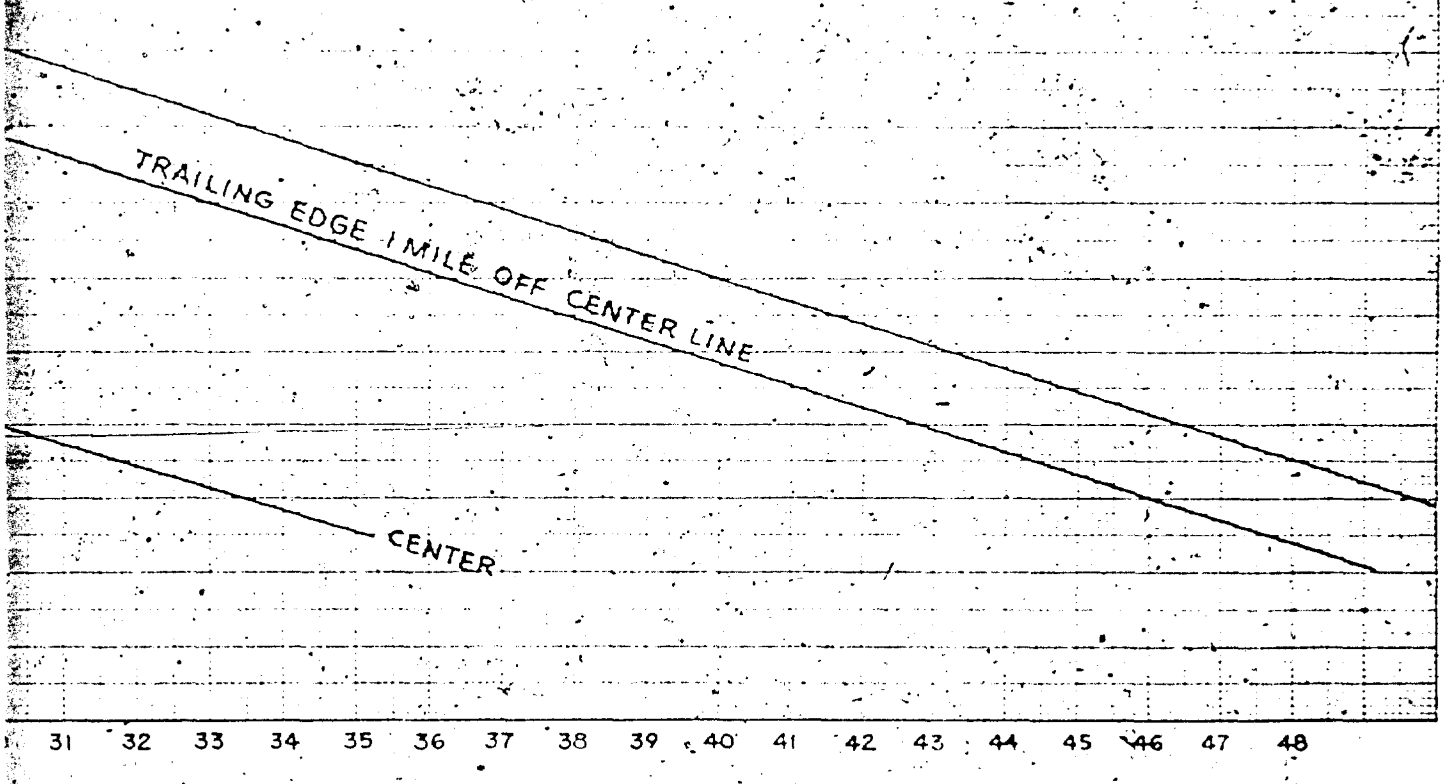

F
MOVEMENT OF BAS
MEASURED FROM
ND EDGE
RADIUS
TRAILING EDGE 1 MILE OFF
CENTER
MILE OFF CENTER LINE
SE
6 [redacted] 18 19 20 21 22 23 24 25 26 28 29 30 31 32 33 34 35 36 37
M[redacted]UTES AFTER EXPLOSION

FIGURE I

MOVEMENT OF BASE SURGE IN A 5 KNOT WIND, MEASURED FROM POINT OF EXPLOSION



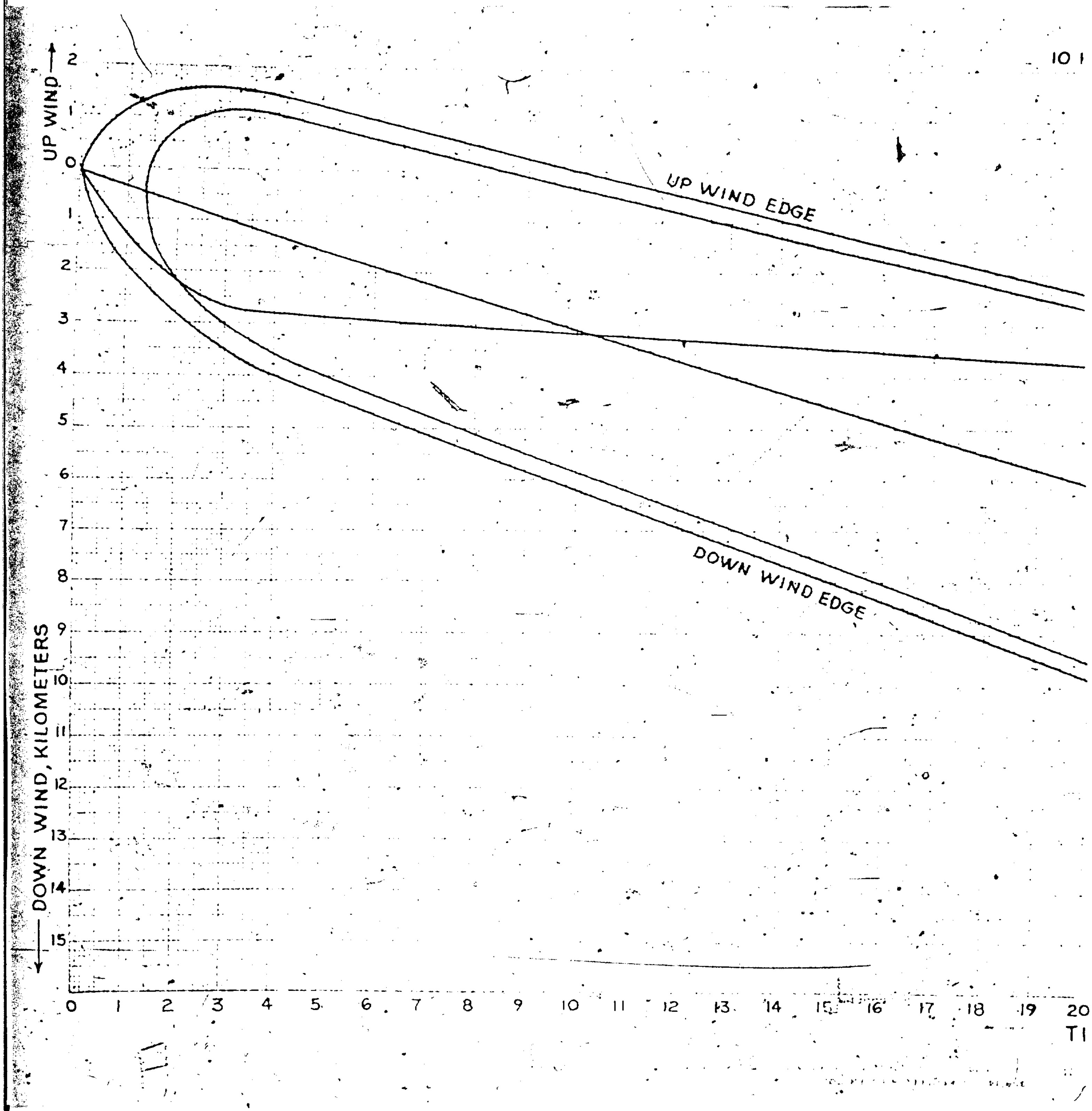
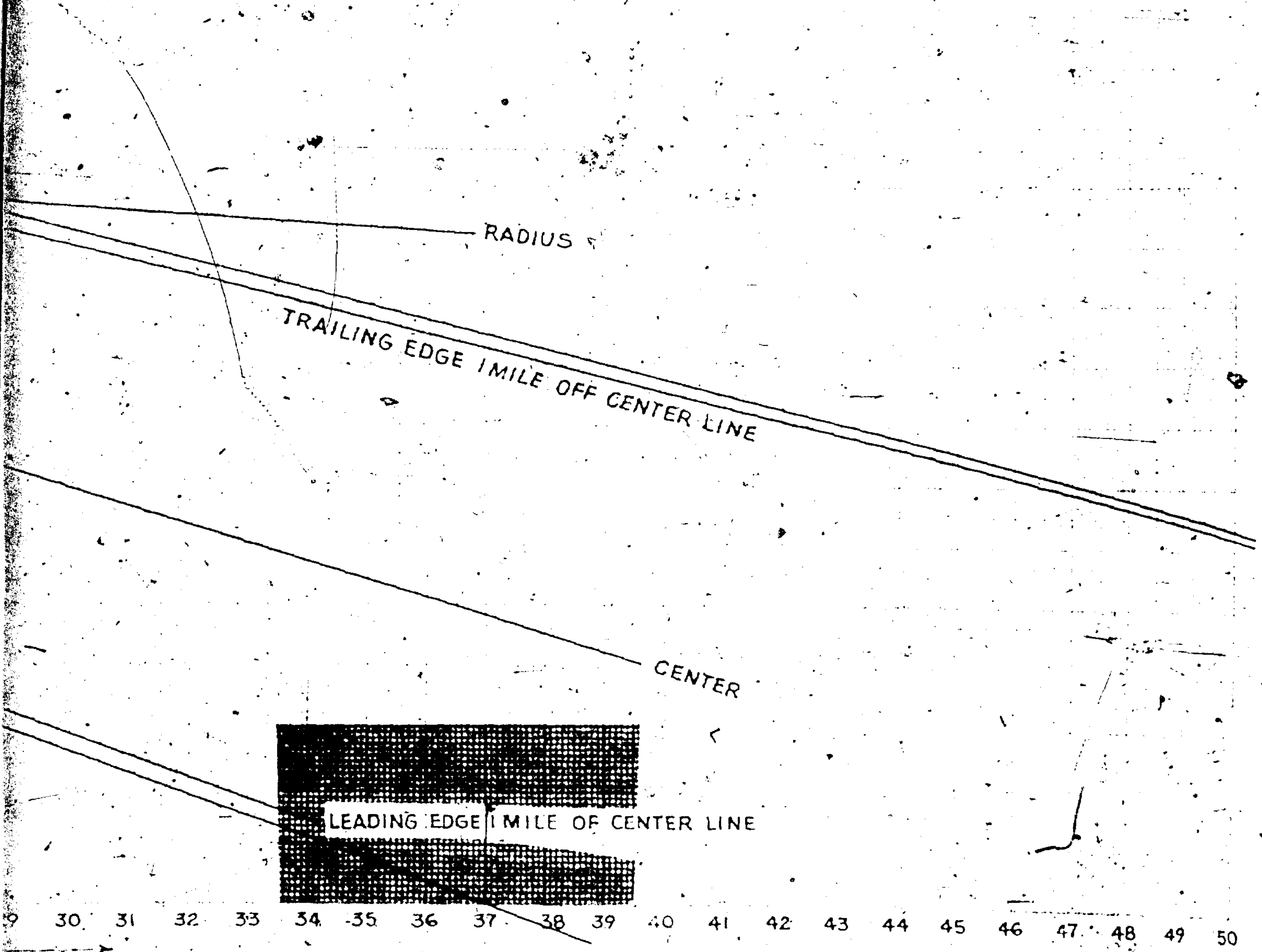

UP WIND
DOWN WIND, KILOMETERS
UP WIND EDGE
DOWN WIND EDGE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TI

FIGURE 2

MOVEMENT OF BASE SURGE IN A 10 KNOT WIND, MEASURED FROM POINT OF EXPLOSION



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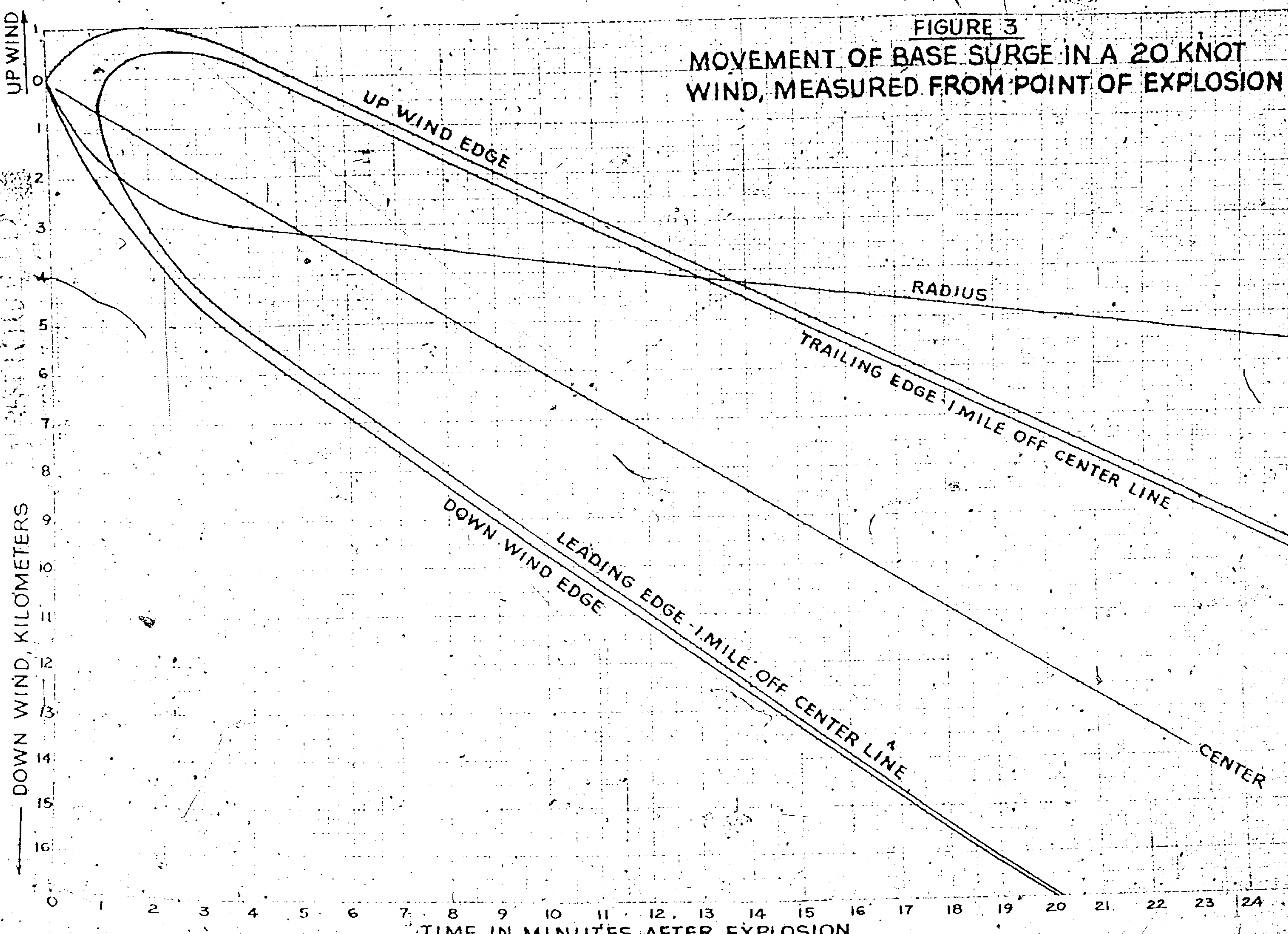
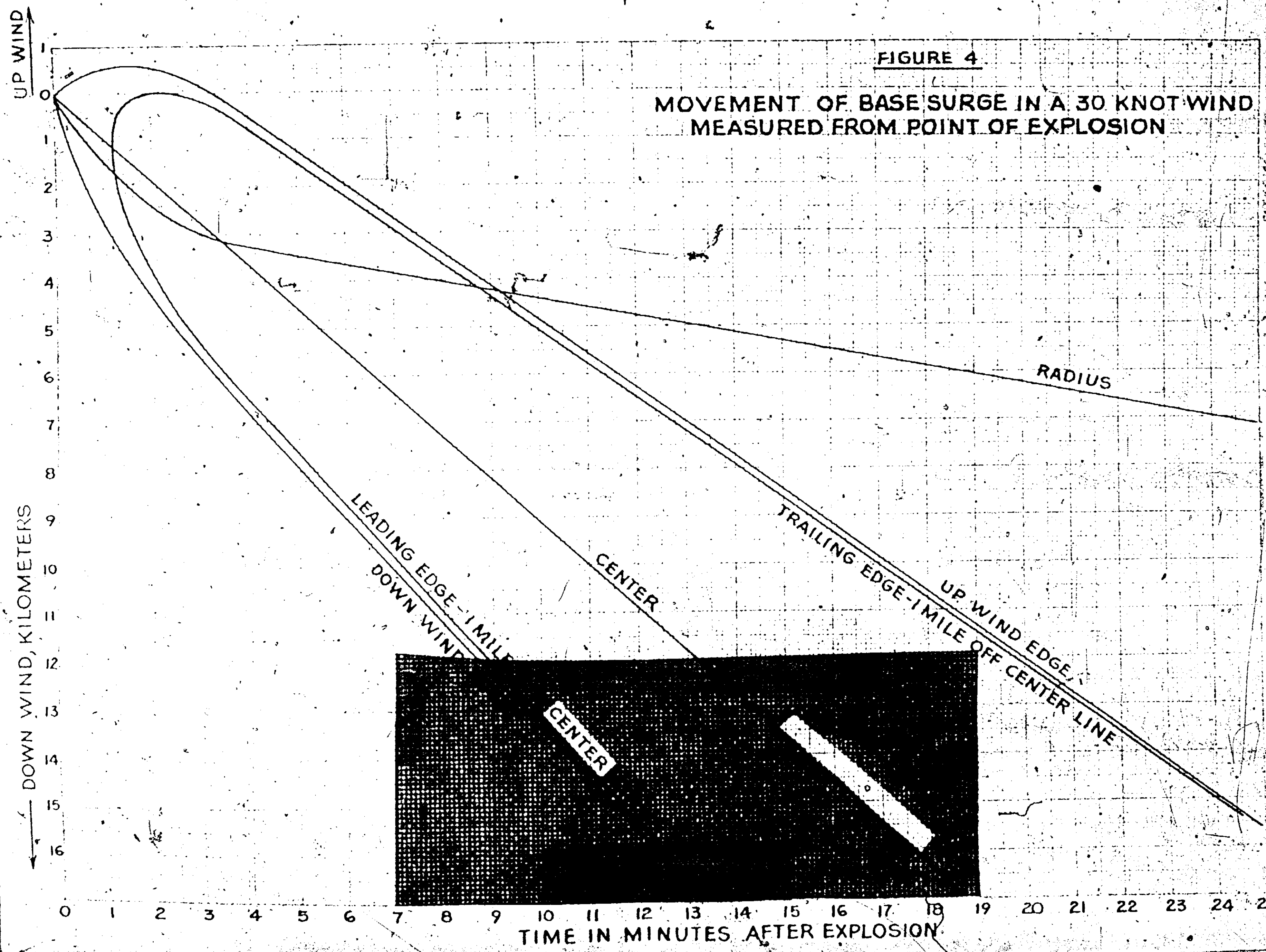


FIGURE 3

MOVEMENT OF BASE SURGE IN A 20 KNOT WIND, MEASURED FROM POINT OF EXPLOSION

FIGURE 4

MOVEMENT OF BASE SURGE IN A 30 KNOT WIND
MEASURED FROM POINT OF EXPLOSION



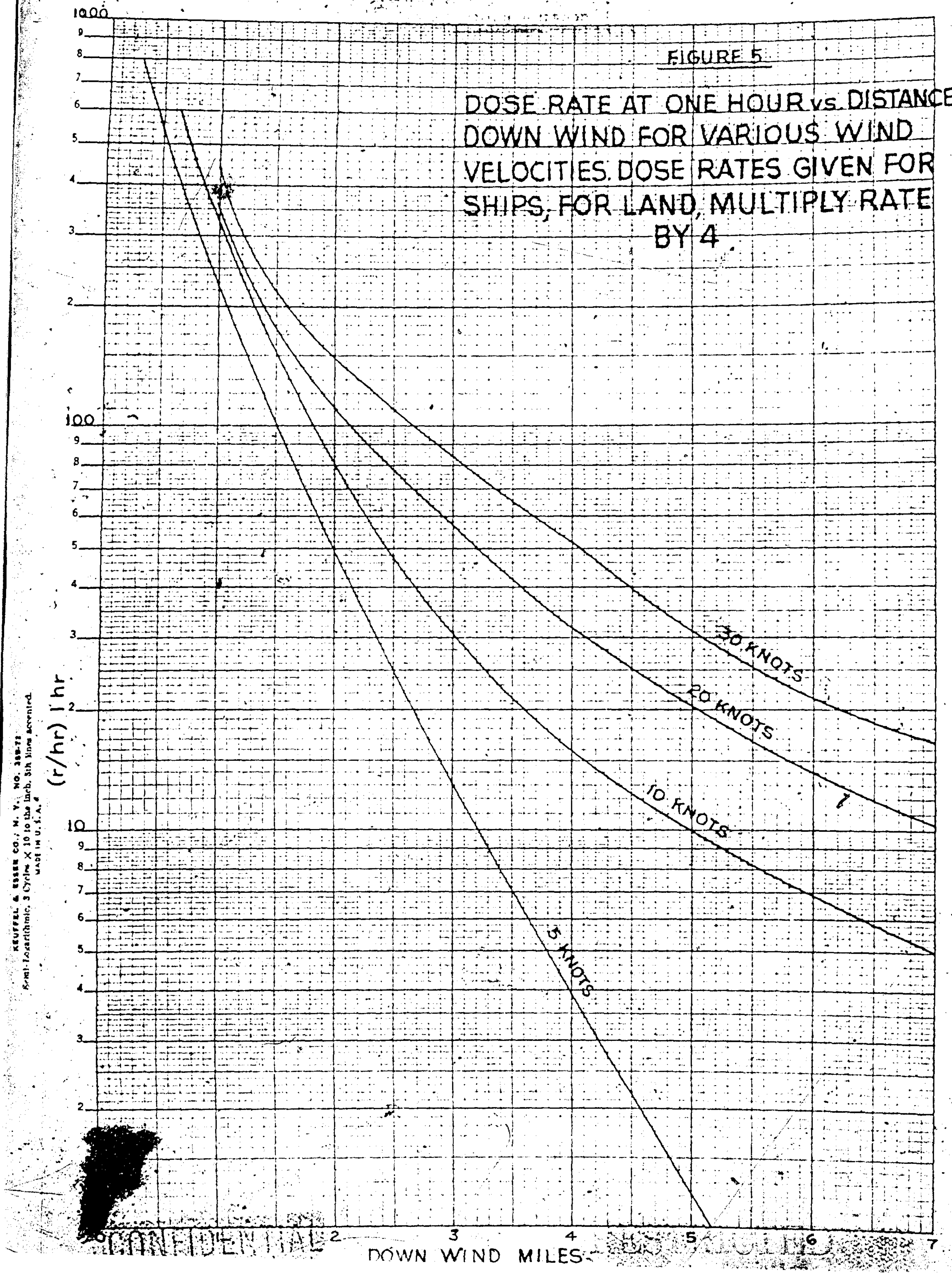


FIGURE 5
DOSE RATE AT ONE HOUR vs. DISTANCE DOWN WIND FOR VARIOUS WIND VELOCITIES. DOSE RATES GIVEN FOR SHIPS, FOR LAND, MULTIPLY RATE BY 4.
(r/hr) 1 hr
DOWN WIND MILES
30 KNOTS
20 KNOTS
10 KNOTS
5 KNOTS
1000
100
10
1
2
3
4
5
6
7
KEUFFEL & ESSER CO., N. Y. NO. 359-72
Semi-Logarithmic, 3 Cycles X 10 to the inch, 5th lines accented.
MADE IN U.S.A.

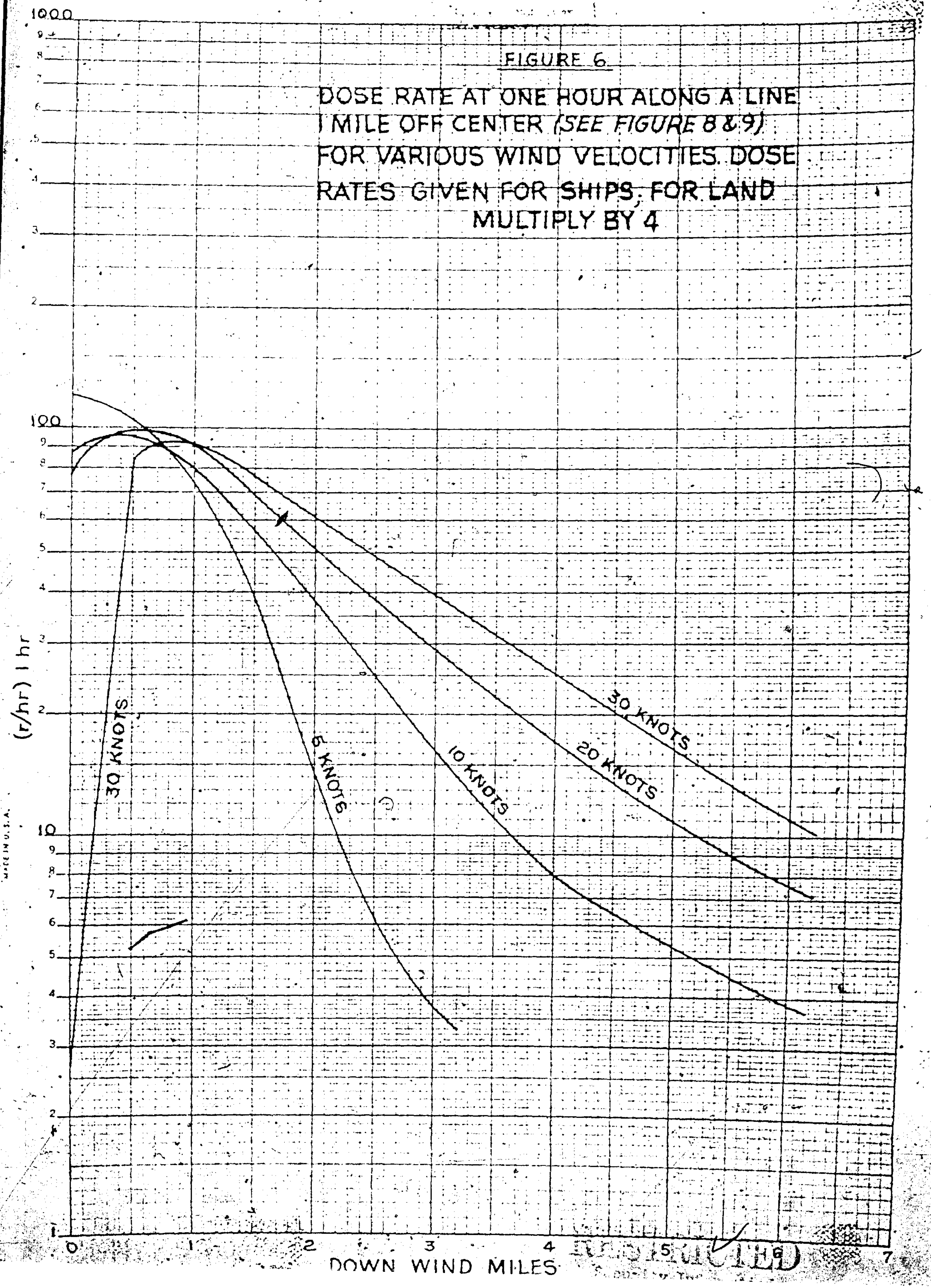


FIGURE 6

DOSE RATE AT ONE HOUR ALONG A LINE 1 MILE OFF CENTER (SEE FIGURE 8 & 9) FOR VARIOUS WIND VELOCITIES. DOSE RATES GIVEN FOR SHIPS, FOR LAND MULTIPLY BY 4

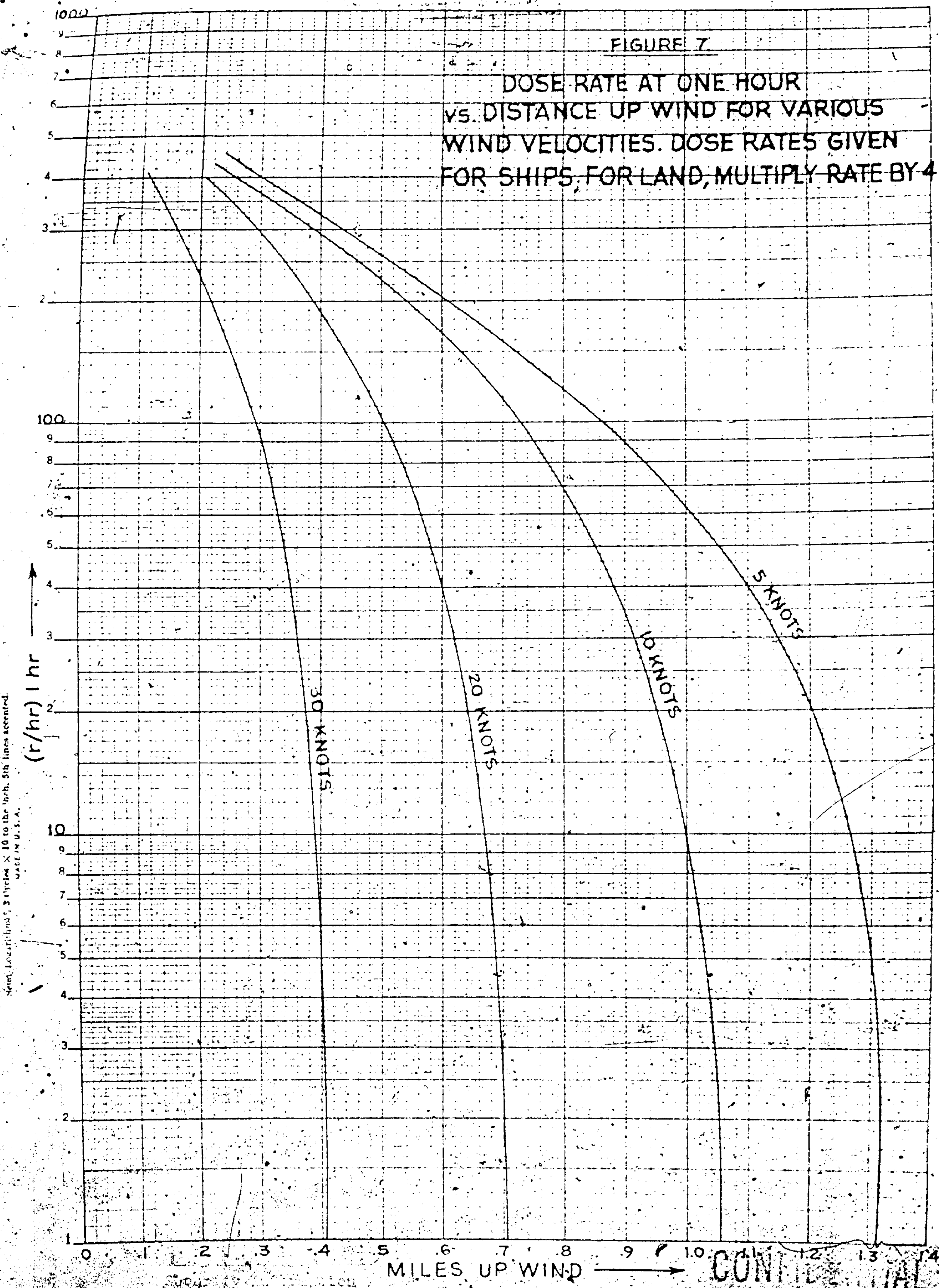


FIGURE 7
DOSE RATE AT ONE HOUR
vs. DISTANCE UP WIND FOR VARIOUS
WIND VELOCITIES. DOSE RATES GIVEN
FOR SHIPS, FOR LAND, MULTIPLY RATE BY 4
5 KNOTS
10 KNOTS
20 KNOTS
30 KNOTS
(r/hr) 1 hr
MILES UP WIND
1000
100
10
1
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
KEUFFEL & ESSER CO., N.Y. NO. 359-72
Semi-Logarithmic, 3 cycles × 10 to the inch, 5th lines accented.
MADE IN U.S.A.

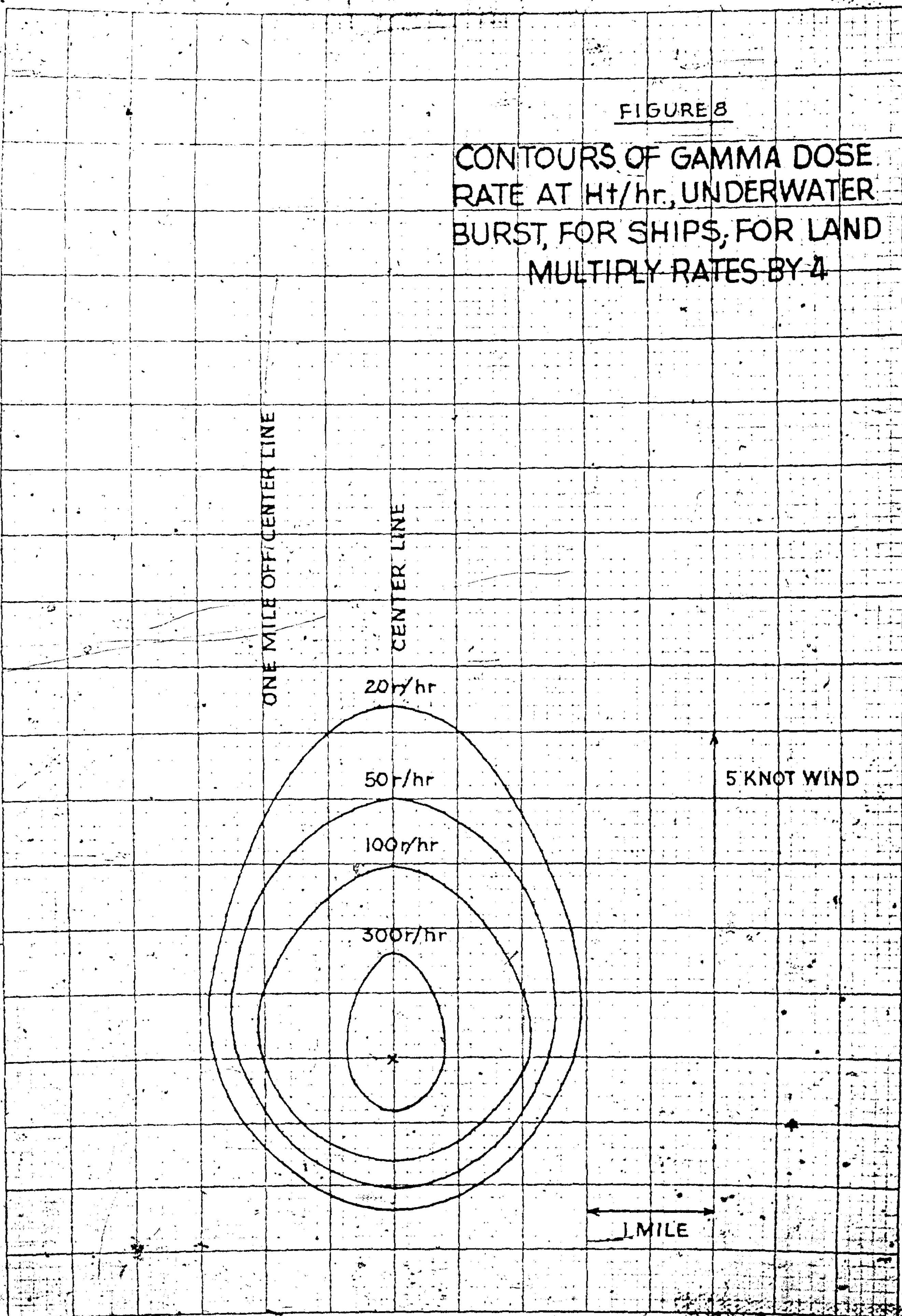


FIGURE 8
CONTOURS OF GAMMA DOSE RATE AT Ht/hr., UNDERWATER BURST, FOR SHIPS, FOR LAND MULTIPLY RATES BY 4
ONE MILE OFF CENTER LINE
CENTER LINE
20 r/hr
50 r/hr
100 r/hr
300 r/hr
5 KNOT WIND
1 MILE
6
5
4
3
2
1
0
1
2
2
1
0
1
2
3

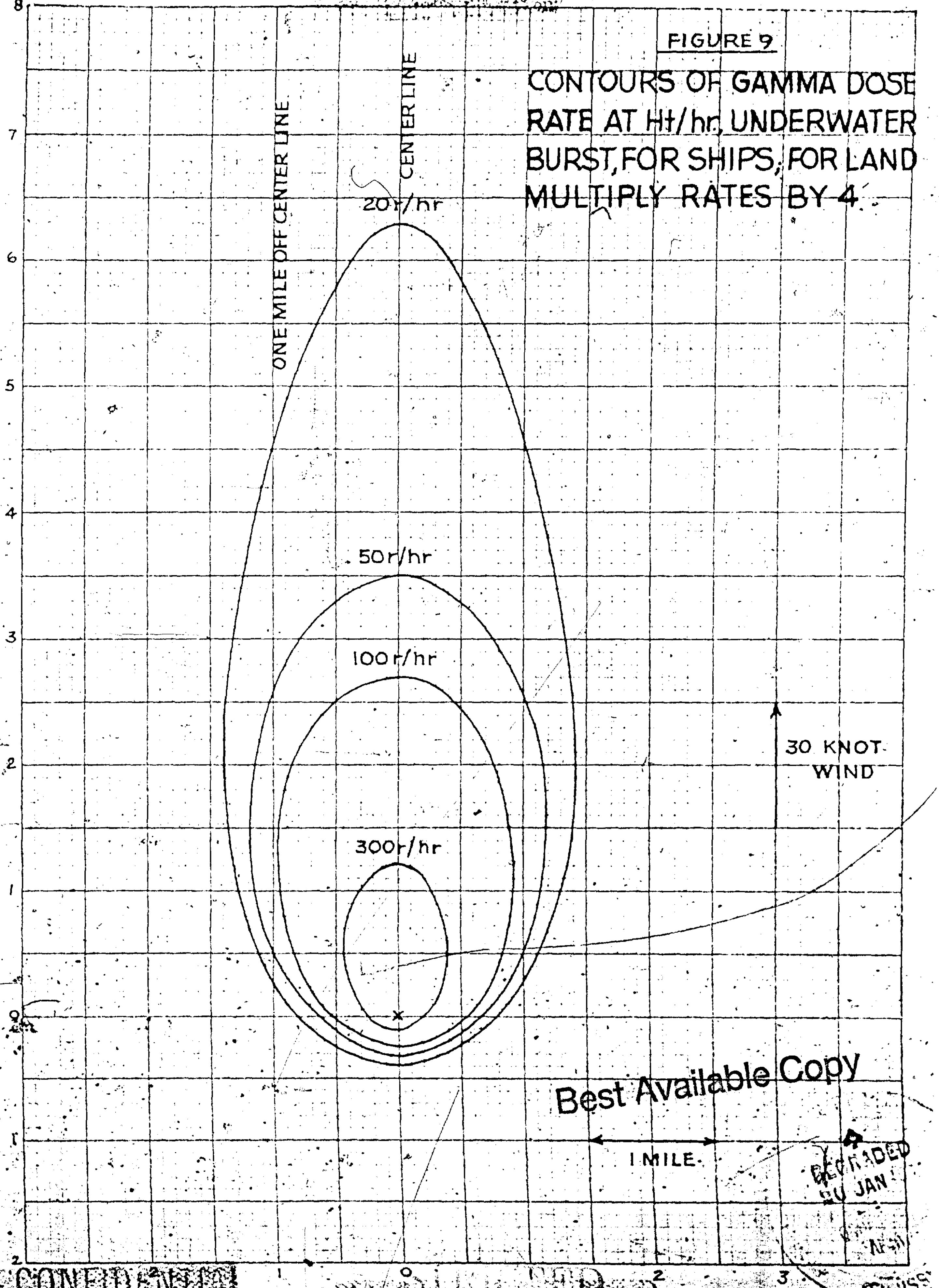


FIGURE 9

CONTOURS OF GAMMA DOSE RATE AT H+/hr. UNDERWATER BURST, FOR SHIPS, FOR LAND MULTIPLY RATES BY 4